EVALUATION OF REMEDIAL ACTIONS TAKEN IN AGRICULTURAL AREA CONTAMINATED BY TRANSURANIDES

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1. INTRODUCTION

In January 17th, 1966 while flying over Palomares (Almería) in the Southeast of Spain two United States Air Force planes collided while on a mid-air fuel supply operation. One of the planes carrying four thermonuclear weapons, three of which, one intact were found on land in the vecinity of Palomares, 24 hours after the destruction of the planes. The fourth thermonuclear weapon was found in the Mediterranean Sea in April 7th. The parachutes of two bombs did not function, causing the detonation of the conventional explosives within them. Thus, releasing their fisionable material and igniting part of it. The aerosol formed by the ignition of the fisionable material produced a contaminating cloud which covered 226 hectares (558 acres) of uncultivated farm and urban land. (See figure 1).

Bomb number 2, for the purpose of this study, landed about one mile to the West of Palomares (impact point number 2) and the plutonium - bearing dust cloud was carried by 30-knot West winds, over non-cultivated terrain, irrigated fields and the northern edge of the village. The cloud from impact point 3, located in the east edge of the village, traveled away from the village but across farmed areas.

An assessment of the situation began shortly after the crash. Visible fragments of both, bombs and air crafts were recuperated, proceeding to determine the levels of alpha contamination in soil, vegetation, houses and area residents. Superficial alpha contamination levels were measured with PAC-15 alpha detectors.

Figure 1 shows the various levels of surface alpha contamination produced and the extension corresponding to each level of alpha contamination. The highest levels of contamination were found in non-cultivated lands located between small hills 1.500 meters southeast of town.

Contaminated vegetation was recuperated, treated and considered as radioactive waste.

Table 1 shows remedial actions taken regarding the affected lands according to the knowledge of the time so there would not be any unacceptable risk in the short and long term contamination of the crops in the area. Ten centimeters of top soil were removed in the areas were superficial alpha concentration was 1200 kBq/m^2 or higher. This material was sealed in containers and sent to the United States. Arable land with levels below 1200 kBq/m^2 were wet down, plowed to a 30 cm depth, harrowed and mixed. On rocky hillsides in area 2, where plowing was not possible, soil with plutonium level above 120 kBq/m^2 was removed in some degree by hand tools.

TABLE 1. REMEDIAL ACTIONS TAKEN AT PALOMARES

LOCATION	SURFACE	REMEDIATION
Impact point 2	1.6 Ha	Removed top 10 cm
Impact point 3	0.6 Ha	Removed top 10 cm
Remainder	224 Ha	Plowed to 30 cm where possible

Once remedial actions were completed and radioactive wastes were removed, an experimental radiological surveillance program was established in order to study long term environmental effects.

Figure 1 shows the location of the six 50 x 50 m study plots established in order to comply with the objectives of the short and long term investigation program on residual plutonium contamination on lands and their effect over farming crops produced in the areas. These study plots have been yearly surveyed since cultivation began to determine contamination by $^{239}Pu+^{240}Pu$ of agricultural products. However, since the study plots have not been cultivated yearly due to diverse reasons, since 1978, sampling has been extended to neighboring areas where residual $^{239}Pu+^{240}Pu$ was similar.

Farming procedures in the area are typical of Mediterranean agricultura zones of scarce yearly precipitation in the order of 200 l/m^2 which require artificial means of irrigation. Until recent years irrigation by flooding with water pumped from wells in the area was prevailing system. Recently, specially, in the production of tomatoes, melons, etc. a drop to drop system is used. For cereals and alfalfa flooding procedures and sometimes aspersion systems are still in use.

This report deals specifically with the evaluation of the remedial actions taken in the area, through the incidence of plutonium contamination in agriculture products produced in the area, and, therefore, the risks to individuals derived from the use of this products through their direct and indirect consumption, ie. animal feed.

Towards this end, we shall expose the results of the field work and their application in order to determine the dose, which has allowed us to arrive to some conclusions in relation to:

a) Evolution of $^{239}Pu+^{240}Pu$ concentrations in soil of cultivated plots.

b) Concentration of $^{239}Pu+^{240}Pu$ in the areas main crops (tomatoes, barley and alfalfa) through a long period of time.

c) Relation of $^{239}Pu+^{240}Pu$ concentrations in soils and vegetation in order to estimate transference factors due to agricultural practice typical in the area and its weather conditions.

d) Concentration of $^{239}Pu+^{240}Pu$ in the totality of annual crops by hectare for each principal crop, and in consideration of the estimated transference ratios.

e) Collective committed effective dose equivalent, $S_{E,70}$, resultant from direct ingestion by humans of annual tomato crops by a cultivated hectare, and in meat, milk of cows, pigs, etc. consuming animal feed from the area.

f) Collective risk derived from the remedial actions taken in the area and deduction of intervention levels towards the application of these remedial actions in the agricultural zones and with similar crops and characteristics as in Palomares, affected by plutonium contaminated aerosols.

2. FIELD EXPERIMENTS AND RESULTS

The field experimentation carried out along the years and the results obtained are expounded below.

2.1 PLUTONIUM CONCENTRATION IN SOILS.

The soils of Palomares, according to their petrographical composition can be classified as lithograywacke-phylloarenite with a 50% matrix where the granular component (grave-sands) are fragments of rocks, mainly shale-type metamorphic rocks.

The average mineralogical composition is: 38.5% quarz, 39.0% moscovite-illite, 21.4% carbonates (calcite and dolomite), 3% iron oxides and opaque minerals, 1.4% chlorite and 2% vegetable remains. These components represent more than 95% of the total mineral composition.

The medium content of organic carbon is 0.27% and humic acids represent 47% of the total organic carbons.

In order to study the evolution of Plutonium concentration in the soil due to the agricultural activities in the areas on a long term basis, six study plots (figure 1) were established. These plots were designated as 2-1, 2-2, 5-1, 5-2, 3-1, 3-2. In order to determine the concentration of plutonium in these plots, periodic sampling has been conducted since 1966 from nine points along the diagonals, equidistant from each other. Each soil sample was 30 milimeter diameter and 45 centimeter deep divided into five sections (0-5, 5-15, 25-35 and 35-45).

Plutonium concentrations in soil samples represent a total of 2160 analysis. The results have shown that plutonium concentrations are heterogenous, but due to farming practices over the years, homogeneity is increasing, always showing a slightly variable concentration in the top soil.

Table 2 shows the average concentration of $^{239}Pu + ^{240}Pu$ in each of the study plots. Due to the fact that plot 2-1 has not been cultivated the plutonium concentration shown corresponds to the top 5 cm.

In all study plots a correlation between the size of soil particles and the concentration of plutonium exist. The largest concentration corresponds to the fraction between 63 and 250 μm. Fractions smaller than 10 μm have only been associated with 15% of the total plutonium activity, increasing the associated percentage in particles of less than 5 μm in the more cultivated terrains.

2.2 PLUTONIUM CONCENTRATIONS IN CULTIVATED CROPS.

The main crops in the area are tomatoes, barley and alfalfa. In the past few years the production of water melons and peppers increased. Corn, beans and other products are only a small percentage of the areas cropped. Thus, our main interest in this report has been the correlation between plutonium concentrations in soil and contamination of tomato, barley and alfalfa crops in the area.

The plan to determine plutonium contamination in the area began in 1968. It sampled and analyzed agricultural products cultivated in the plots used to study the evolution of residual plutonium in the soil.

Vegetation sampling took place within an area of a circunference of a one meter radius. with a center in each of the nine points in the plot where the soil samples were taken. Each sample correspond to a 5-10 kg of weight. When control of other plots in the zone was established in 1978, a radon sampling system was implemented taking 5-10 kg samples of each part of the studied plants.

Many years of sampling have demostrated that not all samples studied, even from the same plot, present plutonium contamination higher than the minimum concentrations detected by our analytical procedures.

Table 3 shows the number of samples analyzed, the percentage of those which show higher than minimum detectable concentration of plutonium and $^{239}Pu+^{240}Pu$ concentration in each of the parts of the agricultural products controlled; this average concentration corresponds to the results of higher minimum detectable concentrations.

As a result of the observation of the samples labeled positive we can deduce that the effect of resuspension of the plutonium particles in soil plays an important role in the contamination of agricultural products cultivated in the area. The highest percentage corresponds to those parts of the plants which present larger surface or higher posibilities of retaining superficial particles (tomato leaves, straw and barley spicules, alfalfa leaves). We shall also considerer important that only 6% of the samples of washed tomatoes show plutonium contamination. Thus, we considerer that a great part of the plutonium contamination in these agricultural products is due to the external surface contamination and not by absorption through the plants'root.

Tables 4, 5, 6 and 7 show the average concentration of $^{239}Pu+^{240}PU$ in tomatoes, barley and alfalfa, corresponding to the samples taken through long periods of time in each of the estudy plots and neighboring areas. These tables also express the values of soil plant concentration ratios. According to these values, and for each and every crop, we can deduce the following:

a) Tomatoes.

The average concentration of $^{239}Pu+^{240}Pu$ in the edible part are comprised between 0.04 and 0.45 Bq x kg^{-1} and are inferior in one order of magnitude to those of the plants, stalk and leaves, which have shown concentration of $^{239}Pu+^{240}Pu$ in the range of 0.04 to 7.68 Bq x kg^{-1}. In washed tomatoes, we have found lower percentage of contaminated samples on top of which the concentration of $^{239}Pu+^{240}Pu$ is in a range of 0.004 to 0.24 Bq x kg^{-1}.

The soil-fruit concentration ratio are in the range 0.38 x 10^{-4}- 2.70 x 10^{-4}. The soil-plant concentration ratio are between 0.04 x 10^{-3} and 5.24 x 10^{-3}.

b) Barley.

Contamination by $^{239}Pu+^{240}Pu$ are different in the diverse parts of the barley plant, which are not generally higher in a scale of magnitude. The average concentration of $^{239}Pu+^{240}Pu$ in the barley grain ranges between 0.34 and 6.00 Bq x kg^{-1}. In the straw it ranges between 1.36 and 12.51 Bq x kg^{-1} and in the spicule between 0.65 and 10.35 Bq x kg^{-1}.

The soil-grain concentration ratios determine range between 2.9×10^{-4} to 4.34×10^{-3}. For the straw, the soil-straw concentration ratio ranges between 2.14×10^{-3} to 1.32×10^{-2}. For the spicule, which is the part of the barley plant not used in animal feed. since it is discarded during the preparation process, the soil-spicule concentration ratios are in the range of 5.9×10^{-4} to 1.97×10^{-2}.

c) Alfalfa.

The average concentration of $^{239}Pu+^{240}Pu$ corresponding to samples of edible parts of the alfalfa obtained in the diverse plots of the area range between 0.90 and 40.30 Bq x kg^{-1}. The values for soil plants concentration ratios range, except for one sample set, between 1.78×10^{-3} to 8.2×10^{-2}.

The range of values corresponding to soil plant concentration ratios obtained from the samples with concentrations of $^{239}Pu+^{240}Pu$ higher than our detectible minimums, and the percentage of samples with positive results, included in Table 3, show to our judgement that the resuspension plays an important role in plutonium contamination in crops produced in the area of which a significant part is of the external surface type.

As a result of the experimental data collected in the field work carried out in the Palomares area, we have concluded that given its climatological conditions and the farming procedures used for each type of crop, the average values of soil-plants concentration ratios are those expressed in Table 7.

2.3 DOSES DERIVED FROM THE CROPS.

Based on the medium of the data obtained yearly regarding the productivity of the crops in the Palomares area, it can be deduced that the annual harvest is the following:

Tomatoes: 80.000 Kg/Ha

Barley:

Grain: 2.500 Kg/Ha

Straw: 2.200 Kg/Ha

Alfalfa: 70.000 Kg/Ha

We have considered to take the maximum conservative stand, which points to the fact that all harvest is contaminated, even though it has been stated that this is not so.

Table 8 shows the values of the collective committed effective dose equivalent. These have been determine after considering the average soil-crop concentration ratios (Table 7), the ingestion to milk transfer coefficients specified for Terra Code (ref. 1) and the highest values of Sv/Bq ratios (ref. 2) for the estimation of the committed effective dose equivalent by means of the ingestion of $^{239}Pu+^{240}Pu$ by individuals of different ages. These values are given to crops cultivated in soils with a concentration of $^{239}Pu+^{240}Pu$ of the 2.1×10^{-3} Bq x Kg^{-1} order.

As a result of this finding, the direct ingestion of non-washed tomatoes produced by hectare, would represent as, a maximum, a collective committed effective dose equivalent, $S_{E,70}$, of 3.0×10^{-3} man Sv x $year^{-1}$ for adults. The individual dose would be on the order of 1.5 µSv x $year^{-1}$ when based on a yearly consumption of 40 Kg of tomatoes.

In cultivation of products which are used for feeding domestic animal in soils with this degree of $^{239}Pu+^{240}Pu$ contamination considerably decreases the value of the collective dose, $S_{E,70}$, for the public, since for each cultivated hectare, and according to the production of alfalfa or barley, the collective doses, $S_{E,70}$, would be represented by the consumption of meat by adults, which runs between the range of 0.6×10^{-9} and 7.9×10^{-9} man Sv x $year^{-1}$ and the consumption of milk by babies which runs between the range of 0.4 x 10^{-9} and 4.7 x 10^{-9} man Sv x $year^{-1}$.

In conclusion the cultivation of soils with a less degree of $^{239}Pu + ^{240}Pu$ contamination will produce lower values of the collective doses, $S_{E,70}$, in a proportional factor to the relation of concentrations of $^{239}Pu + ^{240}Pu$ in the soils. Therefore, the collective dose derived from the cultivated products would be, at least, a 10 factor lower to those expressed in Table 8 in most of the area.

CONCLUSIONS

Field study data obtained through the observation of those crops cultivated in contaminated soils by plutonium, and which were subject to the dilution of superficial contamination by ploughing to a depth of 30–40 cm, as a means of remedial action, allows us to present the following conclusions:

1) In Mediterranean climatological places with scare precipitation, the external surface contamination of those products contaminated by plutonium, by means of resuspension, represents an important process. The values of the soil-crop concentration ratios are in the order of 10^{-4} for tomato fruit and 10^{-3} for the tomato plant and for the diverse components of barley and alfalfa.

2) Dilution by ploughing and homogenization methods used as remedial action in soils with superficial contamination by plutonium on the 120-1200 kBq/m^2 range represents that, for each cultivated hectare for products used as animal feed, the collective committed effective dose equivalent, $S_{E,70}$, proceeding from the beef ingestion of animals fed only with alfalfa or barley (grain and straw) contaminated from these soils, would be, as a maximum, in the order of 10^{-9} man Sv x $year^{-1}$. After the ingestion of milk produced by cows fed with those crops, these would range, as a maximum, in the same order of magnitude, it is to say, about 10^{-9} man Sv x $year^{-1}$ x Ha^{-1}.

This would represent a collective effective dose committment for 10^4 years in the order of 10^{-5} man Sv x Ha^{-1}.

Those products cultivated for human consumption, as tomatoes, for instance, in the zones with this range of contamination by plutonium would represent that for each cultivated hectare, the proceeding $S_{E,70}$ were in the order of 10^{-3} as maximum. However, given the assumptions made from the contamination of the totality of the harvest and the processes to which these products are subject to before their direct ingestion, it would not be a scanty observation to considerer a $S_{E,70}$ in the order of 10^{-4} man Sv x $year^{-1}$. Therefore, the collective effective dose commitment for 10^4 years, would be in the order of 1 man Sv by hectare.

The annual committed effective dose equivalent to individuals by the ingestion of tomatoes would be 1.5 μSv.

3) IAEA consider 1 man Sv of collective effective dose equivalent commitment as guideline in stablishing exempt quantities and rules for practical application.

To achieve a collective effective dose commitment no higher than 1 man Sv for 10^4 years, as a consequence of individual consumption of foodstuffs cultivated in these soils, it has been deduced:

- In those soils devoted to the cultivation of products used as animal feed, ploughing and homogenization methods up to 30 cm depth are sufficient in soils with surface contamination of plutonium of 1200 kBq/m^2.

Therefore, an Intervention Level of 1200 kBq/m^2 would be deduced in order to apply this remedial action to extensions of 10^4 - 10^6 hectares devoted to this type of crops.

- In soils devoted to the harvest of products for man's direct ingestion, it is considered that the plougning and homogenization methods up to a 30 cm depth is sufficient remedial action for the application to soils with a superficial contamination of plutonium of 120 kBq/m^2.

Therefore, an Intervention Level of 120 kBq/m^2 would be the deduced one in order to implement this remedial action to extensions up to 100 hectares devoted to these crops.

The extension of those contaminated areas and the value of the surface contamination will play an important role in the optimization of the Intervention Levels wich could be applied in the case of an accident. Those variations that could emerge in the knowledge of the transference factors and those of the international acceptable norms for determining the value of the collective dose commitment that establishes the exemption limit shoul also be considered.

R E F E R E N C E S

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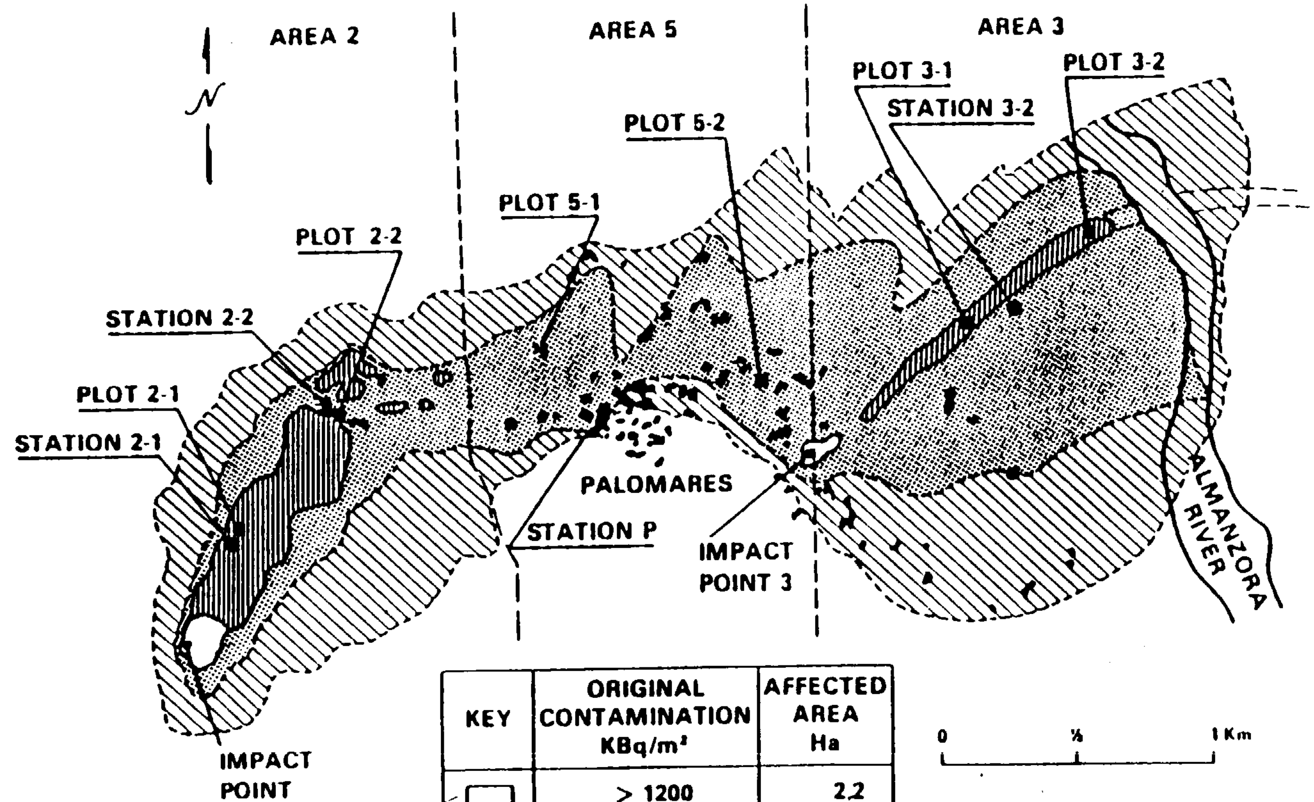
PALOMARES AREA: ORIGINAL CONTAMINATION LEVELS AND LOCATION OF SAMPLING STATIONS



KEY	ORIGINAL CONTAMINATION KBq/m²	AFFECTED AREA Ha
(white)	> 1200	2.2
(vertical lines)	120-1200	17
(stippled)	12-120	87
(diagonal hatching)	< 12	120

removal of 10 cm of top soil

Other areas were wetted and plowed to depth of 30 cm and mixed. (192)

REMEDIAL ACTIONS TAKEN AT PALOMARES FOLLOWING THE JANUARY, 1966, ACCIDENT

Location	Hectares*	Acres	Remediation
Impact Point 2	1.6	4	Removed top 10 cm
Impact Point 3	0.6	1.5	Removed top 10 cm
Remainder	224	550	Plowed to 30 cm where possible
Total	226	558	

*259 hectares equal one square mile.

Table 2.- CONCENTRATION OF PLUTONIUN IN STUDY PLOTS.

PLOT	2-1	2-2	3-1	3-2	5-1	5-2
$^{239}Pu + ^{240}Pu$ Concentration $\bar{X}$, K Bq x Kg^{-1}	0.44	2.1	1.1	1.8	0.13	0.29

Table 3.- PLUTONIUM CONCENTRATIONS IN CULTIVATED CROPS FROM PALOMARES.

PLANT		N° SAMPLES		Pu Conc., Bq x Kg^{-1}
Species	Part	Total	% Positive	$\bar{X}$ in positives
TOMATO	Fruit	159	28.3	0.22
TOMATO	Washed fruit	231	6.1	0.15
TOMATO	Plant	206	41.7	4.42
BARLEY	Grain	496	26.8	2.47
BARLEY	Stalk	496	37.0	5.87
BARLEY	Spicule	144	58.3	5.38
ALFALFA	Plant	112	39.0	3.33

Table 4.- PLUTONIUM DISTRIBUTION IN SOILS AND TOMATOES CROPS AND SOIL-PLANT CONCENTRATION RATIOS IN PALOMARES.

Plot	$^{239}Pu + ^{240}Pu$ Concentration in Soil Bq x Kg^{-1}	$^{239}Pu + ^{240}Pu$ Concentration in tomatoes $\bar{X}$, Bq x Kg^{-1}			Soil-plant concentration ratio		
		Fruit	Washed fruit	Plant	Fruit	Washed Fruit	Plant
(2-2)A'	2.1×10^{3}	0.18	0.18	0.56	0.85×10^{-4}	0.85×10^{-4}	0.27×10^{-3}
(2-2)B'	2.1×10^{3}	0.20	0.24	7.68	0.95×10^{-4}	1.14×10^{-4}	3.65×10^{-3}
(2-2)C'	2.1×10^{3}	0.15	0.14	7.20	0.70×10^{-4}	0.70×10^{-4}	3.43×10^{-3}
3-2	1.8×10^{3}	0.45	0.23	3.10	2.50×10^{-4}	1.20×10^{-4}	1.72×10^{-3}
(3-2)A'	1.8×10^{3}	0.28	≤0.0004	6.28	1.60×10^{-4}	—	3.49×10^{-3}
3-1	1.1×10^{3}	0.042	0.004	1.79	0.38×10^{-4}	0.04×10^{-4}	1.63×10^{-3}
(3-1)A'	1.1×10^{3}	0.30	0.21	1.21	2.70×10^{-4}	1.90×10^{-4}	1.10×10^{-3}
(3-1)B'	1.1×10^{3}	0.27	0.02	0.04	2.50×10^{-4}	0.18×10^{-4}	0.04×10^{-3}
5-2	0.29×10^{3}	≤0.0004	≤0.0004	1.52	—	—	5.24×10^{-3}

Table 5.- PLUTONIUM DISTRIBUTION IN SOILS AND BARLEY CROPS AND SOIL-PLANT CONCENTRATION RATIOS IN PALOMARES.

Plot	$^{239}Pu + ^{240}Pu$ Concentration In Soil $Bq \times Kg^{-1}$	$^{239}Pu\ ^{240}Pu$ Concentration in barley $\bar{X}$, $Bq \times Kg^{-1}$			Soil plant concentration ratio		
		Grain	Straw	Spicule	Grain	Straw	Spicule
2-2	2.1×10^{3}	6.00	8.89	2.16	2.86×10^{-3}	4.23×10^{-3}	1.03×10^{-3}
(2-2) A	2.1×10^{3}	0.82	8.94	8.15	0.39×10^{-3}	4.26×10^{-3}	3.88×10^{-3}
(2-2) B	2.1×10^{3}	0.61	4.82	3.28	0.29×10^{-3}	2.30×10^{-3}	1.56×10^{-3}
3-2	1.8×10^{3}	2.67	3.85	5.92	1.48×10^{-3}	2.14×10^{-3}	3.29×10^{-3}
(3-2) A	1.8×10^{3}	4.65	5.28	6.36	2.53×10^{-3}	2.93×10^{-3}	3.53×10^{-3}
3-1	1.1×10^{3}	1.17	2.72	0.65	1.06×10^{-3}	2.47×10^{-3}	0.59×10^{-3}
(3-1) A	1.1×10^{3}	2.29	12.51	5.48	2.08×10^{-3}	11.37×10^{-3}	4.98×10^{-3}
(3-1) B	1.1×10^{3}	0.99	3.05	10.35	0.90×10^{-3}	2.77×10^{-3}	9.40×10^{-3}
(5-2) A	0.29×10^{3}	0.34	1.36	3.14	1.17×10^{-3}	4.69×10^{-3}	10.83×10^{-3}
(5-2) B	0.29×10^{3}	1.26	1.40	2.60	4.34×10^{-3}	4.82×10^{-3}	8.96×10^{-3}
5-1	0.13×10^{3}	0.43	1.71	2.56	3.31×10^{-3}	13.20×10^{-3}	19.70×10^{-3}

Table 6.- PLUTONIUM DISTRIBUTION IN SOILS AND ALFALFA CROPS AND SOIL-PLANT CONCENTRATION RATIOS IN PALOMARES.

Plot	^{239}Pu + ^{240}Pu Concentration in Soil Bq x Kg	^{239}Pu + ^{240}Pu Concentration in alfalfa $\bar{X}$, Bq x Kg^{-1}	Soil-plant concentration ratio
		Plant	Plant
(2-2)A"	2.1×10^{3}	8.40	4.00×10^{-3}
3-2	1.8×10^{3}	3.20	1.78×10^{-3}
3-1	1.1×10^{3}	40.30	36.60×10^{-3}
5-2	0.29×10^{3}	0.90	3.10×10^{-3}
5-1	0.13×10^{3}	0.98	7.54×10^{-3}
(5-1)A"	0.13×10^{3}	1.06	8.15×10^{-3}
(5-1)B"	0.13×10^{3}	0.66	5.10×10^{-3}
(5-1)C"	0.13×10^{3}	0.68	5.23×10^{-3}

Table 7.- SOIL-PLANT CONCENTRATION RATIOS.

PLANT		CONCENTRATION RATIO
SPECIES	PART	
Tomatoes	Fruit	1.5×10^{-4}
"	Washed fruit	0.9×10^{-4}
"	Plant	2.3×10^{-3}
Barley	Grain	1.9×10^{-3}
"	Straw	5.0×10^{-3}
"	Spicule	6.2×10^{-3}
Alfalfa	Edible	8.9×10^{-3}

Table 8.- COLLECTIVE COMMITTED EFFECTIVE DOSE EQUIVALENT BY INGESTION OF FOOD DERIVED FROM ANNUAL CROPS PER HECTARE CULTIVATED IN SOILS WITH A $^{239}Pu + ^{240}Pu$ CONCENTRATION OF 2.1×10^{3} $Bq \times Kg^{-1}$.

CROP			TOMATOES	BARLEY		ALPHALPHA
				Grain	Straw	
$^{239}Pu + ^{240}Pu$ IN ANNUAL CROP $Bq \times Ha^{-1} \times y^{-1}$			25.2×10^{3}	9.98×10^{3}	23.1×10^{3}	130.8×10^{3}
DIRECT CONSUMPTION $S_{E,70}$		Adult	3.02×10^{-3}			
		5 y. old	6.05×10^{-3}			
INDIRECT CONSUMPTION $S_{E,70}$	Beef	Adult		6.0×10^{-10}	1.3×10^{-9}	7.9×10^{-9}
		5y. old		12.0×10^{-10}	2.7×10^{-9}	15.7×10^{-9}
	Milk	Adult		1.2×10^{-10}	2.8×10^{-10}	1.6×10^{-9}
		1y. old		3.6×10^{-10}	8.32×10^{-10}	4.7×10^{-9}